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Cystic artery anatomies in laparoscopic cholecystectomy and literature review

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Abstract
Aim: In laparoscopic surgery, knowing the anatomic variations helps to be ready for any possibilities. In this study, it was aimed to evaluate the cystic artery (CA) variations and frequency in patients who underwent laparoscopic cholecystectomy (LC).
Material and Methods: The study was carried out by reviewing retrospectively the reports and movies of 100 LC. The positions of the cystic artery and cystic duct relative to Calot's triangle (CT) were determined and the frequency of variation was reviewed.
Results: In 82% of our cases, the cystic artery was monitored as a single branch in the CT, whereas two CA were clipped in 12% of cases. In 3 cases in this study, CA went through the caudal of and parallel with the cystic duct, and entered the gall bladder. In one case, the cystic duct passed through the curve formed by the CA. This pattern was named "spiral cystic artery".
Discussion: The anatomy of the components, which make up a CT has so many diversifications that understanding these variations acts as a key role during LC.

Keywords
Laparoscopy, Cholecystectomy, Arteries

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Introduction

LC is the most common operation of the digestive system, as well as the most common laparoscopic procedure [1,2]. Bleeding complications during LC are the most important non-biliary complications (other than anesthesia) and the most common cause of mortality [3]. Arterial injuries during LC cause approximately 1.9% of cases to convert to open surgery [4]. The inability to perceive the anatomy correctly is an important factor both in the formation of bleeding during dissection and in conversion to open surgery [3,5].

CT is the area between the lower surface of the liver, the cystic duct and the common hepatic duct. During LC, the CA is usually detected and ligated within this triangle [6]. For a reliable LC, it is very important to know the possible variations of this region. When the literature was reviewed, it was noticed that there are few studies on cystic artery variations in LC. In our study, we aimed to define how the CA and CT relationship and how the variations look during LC.

Material and Methods

The study was carried out by reviewing retrospectively the reports and movies of 100 LC operations carried out in the General Surgery Clinic of the Faculty of Medicine at Trakya University. All the operations were carried out by the same surgeon. The patients were positioned slightly deviated to the left and their heads raised approximately 30 degrees. A 0-degree camera was used in the operations.

The study is a retrospective study and Ethics Committee Decision was not required for retrospective studies at the time of the study in our university. Informed consent was obtained from each patient before the operations.

Results

In 82% of the cases, the CA in the CT went through the craniomedial of the cystic duct, and was distributed to the neck or body of the gall bladder. In these cases, the superficial and deep branches of the artery branched from a point close to the gall bladder serosa, and the artery was clamped from a single location in operation. In these cases, when the gall bladder was pulled from its fundus, the distance between the cystic duct and CA widened, and they seemed parallel with each other up to the gall bladder. The CA gave a number of tiny branches into the cystic duct during its course. Since two arteries were seen on the cranial side of the cystic duct in 12 (12%) of our cases, they were clipped separately. While the superficial one was close to the cystic duct, the other was close to the liver.

In one of the two cases with right hepatic artery within the CT, right hepatic artery was found so close to the gall bladder serosa that might nearly be called attached. In this case, when the cystic duct was identified, the first visible structure parallel to it gave the impression of a CA (Figure 1). However, due to the very close location of the vessel, the dissection was proceeded with extreme care6 and it was understood that this vessel was not the CA, but the right hepatic artery.

In one of our cases, the CA entered into the CT, but did not show a usual course, passed through the medial side of the cystic duct, passed to the back face of the cystic duct, and made a curve at the caudo-lateral side of the cystic duct. Then the

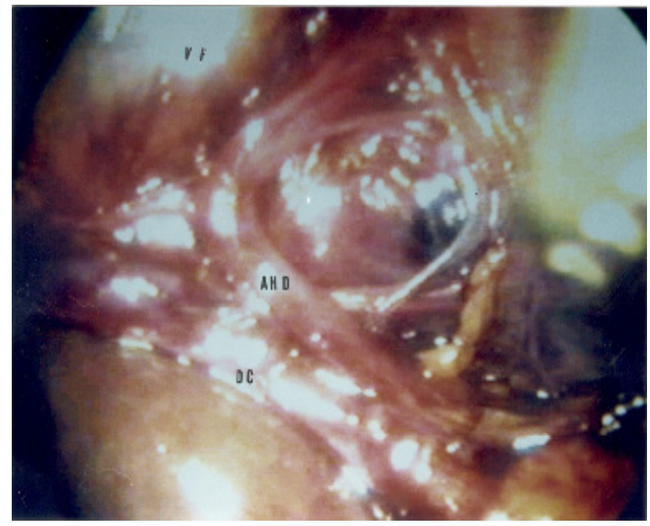

Figure 1. The appearance of a right hepatic artery, located very close to the gallbladder; AHD: Arteria hepatica dextra, DC: Ductus cysticus, VF: Gallbladder

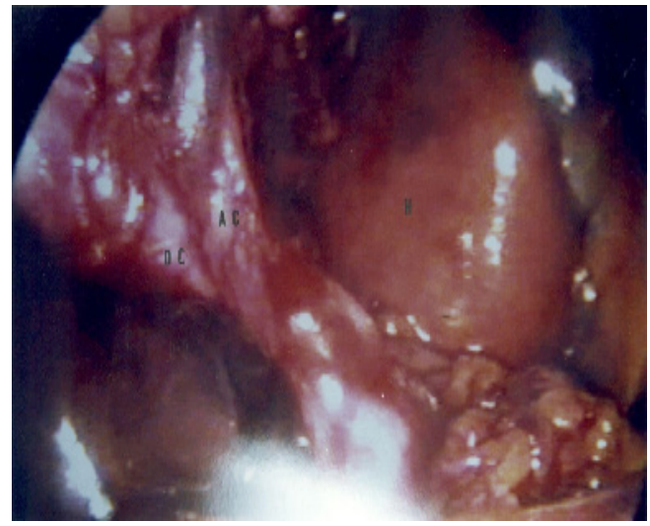

Figure 2. The appearance of the "spiral cystic artery". AC: Arteria cystica, H: Liver, DC

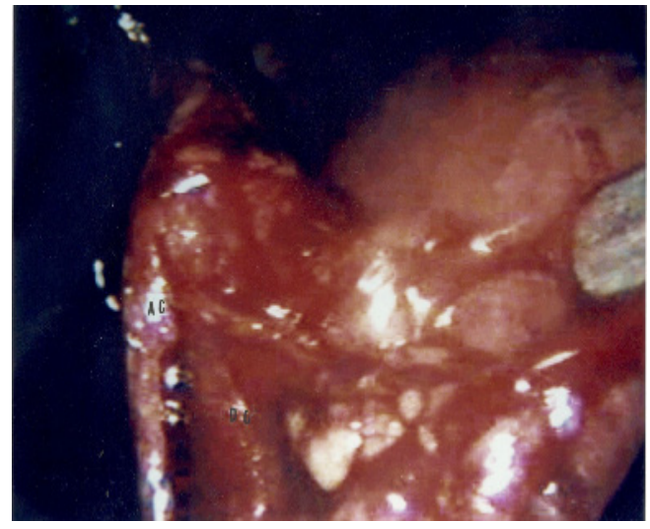

Figure 3. Appearance of the anterior cystic artery AC, DC

CA passed to the front of the cystic duct and entered the gall bladder. In other words, the cystic duct went through the curve formation that was made by CA. This formation was called the ''spiral cystic artery'' (Figure 2).

In three of our cases (3%), the CA did not seem within the CT. The CA went by the caudal of the cystic duct in parallel with this and entered into the gall bladder at the posteroinferior side of the neck portion of the gall bladder (Figure 3). In these cases, CA was the first formation encountered during the Calot dissection in LC. In the LC, the CA is visible in front of the cystic duct. Therefore, it would be appropriate to call it the "anterior course cystic artery".

Discussion

LC has superiorities over open cholecystectomy such as postoperative minimal pain, decreased length of hospital stay, going back to work earlier, and aesthetic results [7]. Even though bile duct injury is one of the most important causes of serious morbidity among LC complications, perioperative bleeding is a complication that cannot be underestimated in terms of its results. Bleeding complications constitute approximately one-third of all major complications in LC. Bleeding remains a frequent reason for conversion to open procedure [2,4,7]. In the study by Sakpal et al, conversion rates due to bleeding constituted 6.4% of all conversion cases [8]. In some studies, the conversion rate from LC to open cholecystectomy has been reported between 2.6% and 8.9% [2,4,9-11]. Uncertain anatomy after adhesions in CT is reported to be the most common cause of conversion with a frequency of 41-42% [9,11].

About 80% of cystic arteries originate from the right hepatic artery. On the other hand, the origins of CA may be the proper hepatic artery, the left hepatic artery, the common hepatic artery, the gastroduodenal artery, celiac artery, and even middle hepatic artery [6,12]. The incidence of a single cystic artery within the CT has been reported with a frequency of 71-76% in various studies. It divides into two branches, one of which is superficial that supplies the ventral side of the gall bladder, and the other is deep that supplies the bed portion between the gall bladder and liver. CA generally branches at the border of the neck or corpus of the gall bladder [3,13-16]. Balija et al. in their study stated that they saw the cystic artery within the Calot's triangle and behind and deep in the cystic duct in 73.5% of cases. They expressed that this artery appeared within the Calot's triangle and in a more lateral position to the cystic duct in open cholecystectomy [13]. In our study, CA was in normal condition in 82 cases (82%). In these cases, CA was observed within the CT and parallel with the cystic duct, on its deeper and posterior side, and in the neighborhood of the Sentinel lymph node. Torres et al. [17] reviewed 88 cases who underwent LC. In cases they named as the standard group, they found out that the cystic artery was located in the anteromedial of the cystic duct and near the sentinel lymph node. The variant group included 32 cases. In 12 of these 32 cases, neither the superficial branch nor the deep branch was dominant. Eight patients had superficial branch predominance. Early division of the cystic artery was observed in 4 patients. Kim et all. [12] stated that they detected CA originating from the middle hepatic artery (MHA) during LC, and that MHA imitated CA. In one of our cases, the right hepatic artery was found to be almost adherent to the gallbladder serosa and it mimicked CA (Figure1). In such cases, if the artery is ligated without careful dissection, liver supply will be damaged [12].

Double CA was reported with a frequency rate of 15-25%. These arteries are generally the branches of the right hepatic artery or of its hepatic segments V or VI. The absence of a posterior branch close to the gallbladder may indicate that there are two cystic arteries [4,13]. In another study, it was determined that there was a double artery within the Calot triangle with a frequency of 15.5% [13]. Ding et al. detected a double cystic artery within the Calot triangle with a frequency of 12.2% in their LC operations [16]. In our study, while the Calot's triangle was explored in 12 (12%) cases, two arteries were determined at the first moment, and these arteries assumed double artery and were clipped separately.

Suzuki et al. [14], in the series covering 244 cases, reported 6 unusual cystic arteries. These arteries first course in the posterior part of the cystic duct, and then pass to the anterior side of the cystic duct, and enter the gallbladder. They named this variation "Cystic Artery Syndrome". Similarly, in one of our cases, CA passed through the medial side of the cystic duct, passed to the back side of the cystic duct, and then made a curve at the caudolateral side of the cystic duct, passing to the front face of the cystic duct. We named this anomalous course of CA "spiral cystic artery" (Figure 2). This is a very rare variation.

If the CA approaches the gall bladder from out of the Calot's triangle, most probably no cystic artery will be observed within the Calot's triangle upon dissection. In one study, the rate of cystic artery outside the Calot triangle was given as 13.3%. However, in this study, CA (1.67%) arising directly from the liver parenchyma were included in this rate [15]. On the other hand, Balija et al. [13] identified a CA originating from the arteria gastroduodenalis with a frequency of 4.5% in their study. This type of CA entered the gall bladder from the Hartmann pouch after passing below the cystic duct. In one study, CA was observed both within and outside of Calot's triangle in 1% of cases, which they called the compound type [15]. In our 3 (3%) cases, the cystic artery was located outside the Calot triangle. It was observed that the CA terminal segment entered into the gall bladder from the lower right of the cystic duct. When dissection was continued, it was observed that the CA went through the caudal side of the cystic duct and parallel with it (Figure 3). In our study, there was no case with double arteries that are observed both outside and within the Calot's triangle.

Conclusion

A rare anatomical variation of CA can be an entrapment leading to serious complications during LC. To conclude, knowing the laparoscopic appearance of the CA course, the frequency of its possible variations, and its relationship with Calot's triangle, is extremely important to prevent iatrogenic injuries and perioperative bleeding. Furthermore, prevention of bleeding is extremely important both to reduce the transition to open surgery and to prevent potential iatrogenic bile duct injuries.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some

of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement
All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest
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